

CLAIMS

We claim:

1. A dual spin valve (SV) sensor, comprising:
a first spin valve (SV) stack;
5 a second spin valve (SV) stack; and
a longitudinal bias stack disposed between said first and
second SV stacks.

2. The dual SV sensor as recited in claim 1, wherein said
10 longitudinal bias stack comprises:

a first ferromagnetic (FM1) layer;
a second ferromagnetic (FM2) layer;
an antiferromagnetic layer disposed between said FM1 and FM2
layers;
15 a first decoupling layer disposed between said first SV
stack and said FM1 layer; and
a second decoupling layer disposed between said FM2 layer
and said second SV stack.

20 3. A dual spin valve (SV) sensor, comprising:

a first spin valve (SV) stack, comprising:
a first antiferromagnetic (AFM1) layer;
a first antiparallel (AP)-pinned layer in contact with
said AFM1 layer;
25 a first sense layer of ferromagnetic material;

a first spacer layer disposed between said first
sense layer and said first AP-pinned layer;
a second spin valve (SV) stack, comprising:
 a second antiferromagnetic (AFM2) layer;
5 a second antiparallel (AP)-pinned layer in contact with
 said AFM2 layer;
 a second sense layer of ferromagnetic material;
 a second spacer layer disposed between said second
 sense layer and said second AP-pinned layer; and
10 a longitudinal bias stack disposed between said first and
 second sense layers, said longitudinal bias stack comprising:
 a first ferromagnetic (FM1) layer;
 a second ferromagnetic (FM2) layer;
 a third antiferromagnetic (AFM3) layer disposed between
15 said FM1 and FM2 layers;
 a first decoupling layer disposed between said first
 sense layer and said FM1 layer; and
 a second decoupling layer disposed between said FM2
 layer and said second sense layer.

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4. The dual SV sensor as recited in claim 3, wherein said
AFM1 and AFM2 layers are made of Pt-Mn.

5. The dual SV sensor as recited in claim 3, wherein said
25 AFM3 layer is made of Ir-Mn.

6. The dual SV sensor as recited in claim 3, wherein a first blocking temperature of the AFM1 and AFM2 layers is greater than a second blocking temperature of the AFM3 layer.

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7. The dual SV sensor as recited in claim 3, wherein said first decoupling layer comprises:

a first sublayer made of Cu-O adjacent to said first sense layer; and

10 a second sublayer made of ruthenium disposed between said first sublayer and said FM1 layer.

8. The dual SV sensor as recited in claim 3, wherein said second decoupling layer comprises:

15 a second sublayer made of Cu-O adjacent to said second sense layer; and

a first sublayer made of ruthenium (Ru) disposed between said second sublayer and said FM2 layer.

20 9. A dual spin valve (SV) sensor, comprising:

a first spin valve (SV) means for providing a first readback signal in response to a magnetic signal field, said first SV means including a first sense layer means responsive to said magnetic signal field;

a second spin valve (SV) means for providing a second readback signal in response to a magnetic signal field, said second SV means including a second sense layer means responsive to said magnetic signal field; and

5 a bias means for providing longitudinal bias fields at said first and second sense layer means to stabilize said first and second SV means, said bias means disposed between said first and second sense layer means.

10 10. A magnetic read/write head, comprising:

a write head including:

at least one coil layer and an insulation stack, the coil layer being embedded in the insulation stack; first and second pole piece layers connected at a back gap and having pole tips with edges forming a portion of an air bearing surface (ABS); the insulation stack being sandwiched between the first and second pole piece layers; and a write gap layer sandwiched between the pole tips of the first and second pole piece layers and forming a portion of the ABS;

a read head including:

a dual spin valve (SV) sensor, the dual SV sensor being sandwiched between first and second shield layers, the dual SV sensor comprising:

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a first spin valve (SV) stack;
a second spin valve (SV) stack; and
a longitudinal bias stack disposed between said
first and second SV stacks; and
5 an insulation layer disposed between the second shield layer
of the read head and the first pole piece layer of the write
head.

11. The magnetic read/write head as recited in claim 10,
10 wherein said longitudinal bias stack comprises:

a first ferromagnetic (FM1) layer;
a second ferromagnetic (FM2) layer;
an antiferromagnetic layer disposed between said FM1 and FM2
layers; and
15 a first decoupling layer disposed between said first SV
stack and said FM1 layer; and
a second decoupling layer disposed between said FM2 layer
and said second SV stack.

20 12. A magnetic read/write head, comprising:
a write head including:
at least one coil layer and an insulation stack, the
coil layer being embedded in the insulation stack;

first and second pole piece layers connected at a
back gap and having pole tips with edges forming a
portion of an air bearing surface (ABS);
the insulation stack being sandwiched between the first
5 and second pole piece layers; and
a write gap layer sandwiched between the pole tips of
the first and second pole piece layers and forming a
portion of the ABS;
a read head including:
10 a dual spin valve (SV) sensor, the SV sensor being
sandwiched between first and second shield layers,
the SV sensor comprising:
a first spin valve (SV) stack, comprising:
a first antiferromagnetic (AFM1) layer;
15 a first antiparallel (AP)-pinned layer in
contact with said AFM1 layer;
a first sense layer of ferromagnetic
material;
a first spacer layer disposed between said
first sense layer and said first AP-pinned
layer;
20 a second spin valve (SV) stack, comprising:
a second antiferromagnetic (AFM2) layer;
a second antiparallel (AP)-pinned layer in
contact with said AFM2 layer;

a second sense layer of ferromagnetic
material;

a second spacer layer disposed between said
second sense layer and said second
AP-pinned layer; and

5 a longitudinal bias stack disposed between said
first and second sense layers, said longitudinal
bias stack comprising:

a first ferromagnetic (FM1) layer;

10 a second ferromagnetic (FM2) layer;

a third antiferromagnetic (AFM3) layer
disposed between said FM1 and FM2 layers;

a first decoupling layer disposed between
said first sense layer and said FM1 layer;

15 and

a second decoupling layer disposed between
said FM2 layer and said second sense layer;
and

an insulation layer disposed between the second shield layer
20 of the read head and the first pole piece layer of the write
head.

13. The magnetic read/write head as recited in claim 12,
wherein said AFM1 and AFM2 layers are made of Pt-Mn.

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14. The magnetic read/write head as recited in claim 12,
wherein said AFM3 layer is made of Ir-Mn.

15. The magnetic read/write head as recited in claim 12
5 wherein a first blocking temperature of the AFM1 and AFM2 layers
is greater than a second blocking temperature of the AFM3 layer.

16. A magnetic read/write head, comprising:
a write head including:

10 at least one coil layer and an insulation stack, the
coil layer being embedded in the insulation stack;
first and second pole piece layers connected at a
back gap and having pole tips with edges forming a
portion of an air bearing surface (ABS);
15 the insulation stack being sandwiched between the first
and second pole piece layers; and
a write gap layer sandwiched between the pole tips of
the first and second pole piece layers and forming a
portion of the ABS;

20 a read head including:
a dual spin valve (SV) sensor, the SV sensor being
sandwiched between first and second shield layers,
the SV sensor comprising:
a first spin valve (SV) means for providing a
25 first readback signal in response to a magnetic

signal field, said first SV means including a
first sense layer means responsive to said
magnetic signal field;
a second spin valve (SV) means for providing a
second readback signal in response to a magnetic
signal field, said second SV means including a
second sense layer means responsive to said
magnetic signal field; and
a bias means for providing longitudinal bias
fields at said first and second sense layer
means to stabilize said first and second SV
means, said bias means disposed between said
first and second sense layer means; and
an insulation layer disposed between the second shield layer
15 of the read head and the first pole piece layer of the write
head.

17. A disk drive system comprising:
a magnetic recording disk;
20 a magnetic read/write head for magnetically recording data
on the magnetic recording disk and for sensing magnetically
recorded data on the magnetic recording disk, said magnetic
read/write head comprising:
a write head including:

at least one coil layer and an insulation stack,
the coil layer being embedded in the insulation
stack;

5 first and second pole piece layers connected at a
back gap and having pole tips with edges forming
a portion of an air bearing surface (ABS);
the insulation stack being sandwiched between the
first and second pole piece layers; and
a write gap layer sandwiched between the pole tips
of the first and second pole piece layers and
forming a portion of the ABS;

10 a read head including:
a dual spin valve (SV) sensor, the SV sensor being
sandwiched between first and second shield
layers, the SV sensor comprising:
a first spin valve (SV) stack;
a second spin valve (SV) stack; and
a longitudinal bias stack disposed between
said first and second SV stacks; and
15 an insulation layer disposed between the second shield
layer of the read head and the first pole piece layer
of the write head;
an actuator for moving said magnetic read/write head across
the magnetic disk so that the read/write head may access
20 different regions of the magnetic recording disk; and
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a recording channel coupled electrically to the write head
for magnetically recording data on the magnetic recording disk
and to the SV sensor of the read head for detecting changes in
resistance of the SV sensor in response to magnetic fields from
5 the magnetically recorded data.

18. The disk drive system as recited in claim 17, wherein
said longitudinal bias stack comprises:

10 a first ferromagnetic (FM1) layer;
 a second ferromagnetic (FM2) layer;
 an antiferromagnetic layer disposed between said FM1 and FM2
layers;
 a first decoupling layer disposed between said first SV
stack and said FM1 layer; and
15 a second decoupling layer disposed between said FM2 layer
and said second SV stack.

19. A disk drive system comprising:

20 a magnetic recording disk;
 a magnetic read/write head for magnetically recording data
on the magnetic recording disk and for sensing magnetically
recorded data on the magnetic recording disk, said magnetic
read/write head comprising:
 a write head including:

at least one coil layer and an insulation stack,
the coil layer being embedded in the insulation
stack;

first and second pole piece layers connected at a
5 back gap and having pole tips with edges forming
a portion of an air bearing surface (ABS);
the insulation stack being sandwiched between the
first and second pole piece layers; and
a write gap layer sandwiched between the pole tips
of the first and second pole piece layers and
10 forming a portion of the ABS;
a read head including:
a dual spin valve (SV) sensor, the SV sensor being
sandwiched between first and second shield
15 layers, the SV sensor comprising:
a first spin valve (SV) stack, comprising:
a first antiferromagnetic (AFM1) layer;
a first antiparallel (AP)-pinned layer
in contact with said AFM1 layer;
a first sense layer of ferromagnetic
20 material;
a first spacer layer disposed between
said first sense layer and said first
AP-pinned layer;
25 a second spin valve (SV) stack, comprising:

a second antiferromagnetic (AFM2) layer;
a second antiparallel (AP)-pinned layer
in contact with said AFM2 layer;
a second sense layer of ferromagnetic
material;

5 a second spacer layer disposed between
said second sense layer and said
second AP-pinned layer; and

a longitudinal bias stack disposed between
10 said first and second sense layers, said
longitudinal bias stack comprising:

a first ferromagnetic (FM1) layer;
a second ferromagnetic (FM2) layer;
a third antiferromagnetic (AFM3) layer
disposed between said FM1 and FM2
15 layers;

a first decoupling layer disposed
between said first sense layer and
said FM1 layer; and

a second decoupling layer disposed
20 between said FM2 layer and said second
sense layer; and

an insulation layer disposed between the second shield
layer of the read head and the first pole piece layer
of the write head; and

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an actuator for moving said magnetic read/write head across the magnetic disk so that the read/write head may access different regions of the magnetic recording disk; and
5 a recording channel coupled electrically to the write head for magnetically recording data on the magnetic recording disk and to the SV sensor of the read head for detecting changes in resistance of the SV sensor in response to magnetic fields from the magnetically recorded data.

10 20. The disk drive system as recited in claim 19, wherein said AFM1 and AFM2 layers are made of Pt-Mn.

21. The disk drive system as recited in claim 19, wherein said AFM3 layer is made of Ir-Mn.

15 22. The disk drive system as recited in claim 19, wherein a first blocking temperature of the AFM1 and AFM2 layers is greater than a second blocking temperature of the AFM3 layer.

20 23. A disk drive system comprising:
a magnetic recording disk;
a magnetic read/write head for magnetically recording data on the magnetic recording disk and for sensing magnetically recorded data on the magnetic recording disk, said magnetic
25 read/write head comprising:

a write head including:

at least one coil layer and an insulation stack,
the coil layer being embedded in the insulation
stack;

5 first and second pole piece layers connected at a
back gap and having pole tips with edges forming
a portion of an air bearing surface (ABS);
the insulation stack being sandwiched between the
first and second pole piece layers; and

10 a write gap layer sandwiched between the pole tips
of the first and second pole piece layers and
forming a portion of the ABS;

a read head including:

a dual spin valve (SV) sensor, the SV sensor being
sandwiched between first and second shield
layers, the SV sensor comprising:

a first spin valve (SV) means for providing a
first readback signal in response to a
magnetic signal field, said first SV means
including a first sense layer means
responsive to said magnetic signal field;

15 a second spin valve (SV) means for providing
a second readback signal in response to a
magnetic signal field, said second SV means
including a second sense layer means

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a second spin valve (SV) means for providing
a second readback signal in response to a
magnetic signal field, said second SV means
including a second sense layer means

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responsive to said magnetic signal field;
and
a bias means for providing longitudinal bias
fields at said first and second sense layer
means to stabilize said first and second
5 SV means, said bias means disposed between
said first and second sense layer means;
an insulation layer disposed between the second shield
layer of the read head and the first pole piece layer
10 of the write head; and
an actuator for moving said magnetic read/write head across
the magnetic disk so that the read/write head may access
different regions of the magnetic recording disk; and
a recording channel coupled electrically to the write head
15 for magnetically recording data on the magnetic recording disk
and to the SV sensor of the read head for detecting changes in
resistance of the SV sensor in response to magnetic fields from
the magnetically recorded data.

20 24. A method of fabricating a dual spin valve (SV) sensor
which comprises the steps of:
a) sputter depositing the multilayer dual SV sensor
including a first spin valve (SV) stack, a second spin valve (V)
stack and a longitudinal bias stack disposed between the first
25 and second SV stacks;

b) annealing the dual SV sensor at a first temperature in a first magnetic field oriented in a transverse direction perpendicular to an air bearing surface; and

c) annealing the dual SV sensor at a second temperature in a 5 second magnetic field oriented in a longitudinal direction parallel to said air bearing surface, wherein said second temperature is less than said first temperature and said second magnetic field has a magnitude smaller than said first magnetic field.

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25. The method of fabricating a dual SV sensor as recited in claim 24, wherein said first temperature is about 280° C and said second temperature is about 240° C.

15 26. The method of fabricating a dual SV sensor as recited in claim 24, wherein said first first magnetic field has a magnitude of about 10,000 Oe and said second magnetic field has a magnitude of about 200 Oe.

20 27. A dual hybrid spin valve (SV)/magnetic tunnel junction (MTJ) sensor, comprising:

a spin valve (SV) stack;

a magnetic tunnel junction (MTJ) stack; and

a longitudinal bias stack disposed between said SV and MTJ 25 stacks.

28. The dual hybrid SV/MTJ sensor as recited in claim 27,
wherein said longitudinal bias stack comprises:
a first ferromagnetic (FM1) layer;
5 a second ferromagnetic (FM2) layer;
an antiferromagnetic layer disposed between said FM1 and FM2
layers;
a first decoupling layer disposed between said SV stack and
said FM1 layer; and
10 a second decoupling layer disposed between said FM2 layer
and said MTJ stack.

29. A dual hybrid spin valve (SV)/magnetic tunnel junction
(MTJ) sensor, comprising:
15 a spin valve (SV) stack, comprising:
a first antiferromagnetic (AFM1) layer;
a first antiparallel (AP)-pinned layer in contact with
said AFM1 layer;
a first sense layer of ferromagnetic material;
20 a first spacer layer disposed between said first
sense layer and said first AP-pinned layer;
a magnetic tunnel junction (MTJ) stack, comprising:
a second antiferromagnetic (AFM2) layer;
a second antiparallel (AP)-pinned layer in contact with
25 said AFM2 layer;

a second sense layer of ferromagnetic material;
a tunnel barrier layer disposed between said second
sense layer and said second AP-pinned layer; and
a longitudinal bias stack disposed between said first and
5 second sense layers, said longitudinal bias stack comprising:
a first ferromagnetic (FM1) layer;
a second ferromagnetic (FM2) layer;
a third antiferromagnetic (AFM3) layer disposed between
said FM1 and FM2 layers;
10 a first decoupling layer disposed between said first
sense layer and said FM1 layer; and
a second decoupling layer disposed between said FM2
layer and said second sense layer.

15 30. The dual hybrid SV/MTJ sensor as recited in claim 29,
wherein said AFM1 and AFM2 layers are made of Pt-Mn.

31. The dual hybrid SV/MTJ sensor as recited in claim 29,
wherein said AFM3 layer is made of Ir-Mn.

20 32. The dual hybrid SV/MTJ sensor as recited in claim 29,
wherein a first blocking temperature of the AFM1 and AFM2 layers
is greater than a second blocking temperature of the AFM3 layer.

33. The dual hybrid SV/MTJ sensor as recited in claim 29,
wherein said first decoupling layer comprises:

a first sublayer made of Cu-O adjacent to said first sense
layer; and.

5 a second sublayer made of ruthenium (Ru) disposed between
said first sublayer and said FM1 layer.

34. The dual hybrid SV/MTJ sensor as recited in claim 29,
wherein said second decoupling layer comprises:

10 a second sublayer made of Cu-O adjacent to said second sense
layer; and

 a first sublayer made of ruthenium (Ru) disposed between
said second sublayer and said FM2 layer.

15 35. A dual hybrid spin valve (SV)/magnetic tunnel junction
(MTJ) sensor, comprising:

 a spin valve (SV) means for providing a first readback
signal in response to a magnetic signal field, said SV means
including a first sense layer means responsive to said magnetic
20 signal field;

 a magnetic tunnel junction (MTJ) means for providing a
second readback signal in response to a magnetic signal field,
said MTJ means including a second sense layer means responsive to
said magnetic signal field; and

a bias means for providing longitudinal bias fields at said first and second sense layer means to stabilize said SV and MTJ means, said bias means disposed between said first and second sense layer means.